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<b>(21) International Application Number:</b> PCT/SE96/01579 <b>(22) International Filing Date:</b> 29 November 1996 (29.11.96)  <b>(30) Priority Data:</b> 9504304-8 30 November 1995 (30.11.95) SE 9603662-9 4 October 1996 (04.10.96) SE  <b>(71) Applicant (for all designated States except US):</b> SANDVIK AB (publ) [SE/SE]; S-811 81 Sandviken (SE).  <b>(72) Inventors; and</b> <b>(75) Inventors/Applicants (for US only):</b> SANDMAN, Annika [SE/SE]; Grusåsgränd 110, BV, S-121 30 Enskededalen (SE). ODEN, Camilla [SE/SE]; Igeldammsgatan 20, S-112 49 Stockholm (SE). PERSSON, Jeanette [SE/SE]; Hästhagsvägen 11, S-131 33 Nacka (SE). ÖSTLUND, Åke [SE/SE]; Sedelvägen 12, S-129 32 Hägersten (SE).  <b>(74) Agents:</b> ÖSTLUND, Alf et al.; Sandvik AB, Patent Dept., S-811 81 Sandviken (SE).		<b>(81) Designated States:</b> BR, CN, IL, JP, KR, US, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).  <b>Published</b> <i>With international search report.</i>
<b>(54) Title:</b> COATED CUTTING INSERT AND METHOD OF MAKING IT		
<b>(57) Abstract</b>  The present invention discloses a coated cutting tool insert particularly useful for dry and wet machining in low and medium alloyed steels, stainless steels, with or without raw surface zones under severe conditions such as vibrations, long overhang and recutting of chips. The insert is characterized by a WC-Co cemented carbide with a low content of cubic carbides and a rather low W-alloyed binder phase and a coating including an innermost layer of $TiC_xN_yO_z$ with columnar grains and a top layer of TiN and an inner layer of $\kappa-Al_2O_3$ . The layers are deposited by using CVD-methods.		

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## COATED CUTTING INSERT AND METHOD OF MAKING IT

The present invention relates to a coated cutting tool (cemented carbide insert) particularly useful for  
5 toughness demanding wet and dry machining, preferably milling, of low and medium alloyed steels and stainless steels, with raw surfaces such as cast skin, forged skin, hot or cold rolled skin or pre-machined surfaces under unstable conditions.

10 When machining low and medium alloyed steels and stainless steels with cemented carbide tools the cutting edge is worn according to different wear mechanisms, such as chemical wear, abrasive wear, adhesive wear and by edge chipping caused by cracks formed along the  
15 cutting edge, the so called comb cracks. In bad conditions problems with bulk and edge line breakages occur commonly.

Different cutting conditions require different properties of the cutting insert. For example, when  
20 cutting in steels with raw surface zones or cutting under difficult conditions a coated cemented carbide insert must consist of a tough carbide and have very good coating adhesion. When machining in low alloyed steels and stainless steels the adhesive wear is  
25 generally the dominating wear type. Here generally 1-3  $\mu\text{m}$  CVD- or PVD-coatings have to be used.

Measures can be taken to improve the cutting performance with respect to a specific wear type. However, very often such action will have a negative  
30 effect on other wear properties.

The influence of some possible measures is given below:

1.) Comb crack formation can be reduced by lowering the binder phase content. However, such action will  
35 lower the toughness properties of the cutting inserts

which is not desirable.

2.) Improved abrasive wear can be obtained by increasing the coating thickness. However, thick coatings increase the risk for flaking and will lower  
5 the resistance to adhesive wear.

3.) Machining at high cutting speeds and at high cutting edge temperatures requires a cemented carbide with a rather high amount of cubic carbides (solid solution of WC-TiC-TaC-NbC). Such carbides will more  
10 easily develop comb cracks.

4.) Improved toughness can be obtained by increasing the Co-content. However, high Co-content will decrease the plastic deformation resistance.

So far it has been very difficult to improve all  
15 tool properties simultaneously. Commercial cemented carbide grades have therefore been optimized with respect to one or few of these wear types and hence to specific application areas.

Swedish patent application 9504304-8 discloses a  
20 coated cutting insert particularly useful for milling in low and medium alloyed steel with or without raw surface zones during wet or dry conditions. The insert is characterized by WC-Co cemented carbide with a low content of cubic carbides and a highly W-alloyed binder  
25 phase and a coating including an innermost layer of  $TiC_xN_yO_z$  with columnar grains and a top layer of TiN and an inner layer of  $K-Al_2O_3$ .

Swedish patent application 9501286-0 discloses a coated cutting insert particularly useful for dry  
30 milling of grey cast iron. The insert is characterized by a straight WC-Co cemented carbide grade and a coating including a layer of  $TiC_xN_yO_z$  with columnar grains and a top layer of fine grained textured  $\alpha-Al_2O_3$ .

Swedish patent application 9502640-7 discloses a  
35 coated turning insert particularly useful for

intermittent turning in low alloyed steel. The insert is characterized by a WC-Co cemented carbide body having a highly W-alloyed Co-binder phase and a coating including a layer of  $TiC_xN_yO_z$  with columnar grains and a top layer of a fine grained, textured  $\alpha-Al_2O_3$ .

Swedish patent application 9503056-5 discloses a coated turning cutting tool particularly useful for cutting in hot and cold forged low alloyed steel. The insert is characterized by a WC-Co cemented carbide body having a highly W-alloyed Co-binder phase and a coating including a layer of  $TiC_xN_yO_z$  with columnar grains and a top layer of a fine-grained,  $\alpha-Al_2O_3$ .

Swedish patent application 9602413-8 discloses a coated turning insert particularly useful for turning in stainless steel. The insert is characterised by WC-Co-based cemented carbide substrate having a highly W-alloyed Co-binder phase and a coating including an innermost layer of  $TiC_xN_yO_z$  with columnar grains and a top layer of TiN and an inner layer of fine grained  $K-Al_2O_3$ .

It has now surprisingly been found that by combining many different features a cutting tool, preferably for milling, can be obtained with excellent cutting performance in low and medium alloyed steel, with or without raw surface zones preferably under unstable conditions such as vibrations, long overhang, chip-hammering or recutting of chips or in generally toughness demanding operations both in wet and dry conditions. It has also been found that this specific cutting tool also works in stainless steel. The cutting tool according to the invention shows improved properties with respect to many of the wear types earlier mentioned.

The cutting tool insert according to the invention consists of: a cemented carbide body with a rather low

W-alloyed binder phase and with a well balanced chemical composition and grain size of the WC, a columnar  $\text{TiC}_x\text{N}_y\text{O}_z$ -layer, a  $\kappa\text{-Al}_2\text{O}_3$ -layer, a TiN-layer and optionally followed by smoothening the cutting edges by  
5 brushing the edges with e.g. a SiC based brush.

According to the present invention a coated cutting tool insert is provided consisting of a cemented carbide body with a composition of 10.9-13 wt% Co, preferably 11.0-12.0 wt% Co, most preferably 11.1-11.7 wt% Co, 0.2-  
10 1.8 wt% cubic carbides, preferably 0.4-1.8 wt% cubic carbides, most preferably 0.5-1.7 wt% cubic carbides of the metals Ta, Nb and Ti and balance WC. The cemented carbide may also contain other carbides from elements from group IVb, Vb or VIb of the periodic table. The  
15 content of Ti is preferably on a level corresponding to a technical impurity. The average grain size of the WC is in the range of about 1.5-2.5  $\mu\text{m}$ , preferably about 1.7  $\mu\text{m}$ .

The cobalt binder phase is rather low alloyed with  
20 W. The content of W in the binder phase can be expressed as the CW-ratio=  $M_s / (\text{wt\% Co} \cdot 0.0161)$ , where  $M_s$  is the measured saturation magnetization of the cemented carbide body in kA/m and wt% Co is the weight percentage of Co in the cemented carbide. The CW-value is a  
25 function of the W content in the Co binder phase. A high CW-value corresponds to a low W-content in the binder phase.

It has now been found according to the present invention that improved cutting performance is achieved  
30 if the cemented carbide body has a CW-ratio of 0.87-0.99, preferably 0.88-0.97, and most preferably 0.90-0.95. The cemented carbide may contain small amounts, <1 volume %, of  $\eta$ -phase ( $\text{M}_6\text{C}$ ), without any detrimental effect. From the CW-value it follows that no free  
35 graphite is allowed in the cemented carbide body

according to the present invention.

The coating comprises

- a first (innermost) layer of  $\text{TiC}_x\text{N}_y\text{O}_z$  with  $x+y+z=1$ , preferably  $y>x$  and  $z<0.2$ , most preferably  $y>0.8$  and  $z=0$ , with equiaxed grains with size  $<0.5\text{ }\mu\text{m}$  and a total thickness  $<1.5\text{ }\mu\text{m}$  preferably  $>0.1\text{ }\mu\text{m}$ .
- a layer of  $\text{TiC}_x\text{N}_y\text{O}_z$  with  $x+y+z=1$ ,  $\mu\text{m}$  preferably with  $z=0$ ,  $x>0.3$  and  $y>0.3$ , most preferably  $x>0.5$ , with a thickness of  $1\text{-}8\text{ }\mu\text{m}$ , preferably  $2\text{-}7\text{ }\mu\text{m}$ , most preferably  $<6\text{ }\mu\text{m}$ , with columnar grains and with an average diameter of  $<5\text{ }\mu\text{m}$ , preferably  $0.1\text{-}2\text{ }\mu\text{m}$
- a layer of a smooth, fine-grained (grain size about  $0.5\text{-}2\text{ }\mu\text{m}$ )  $\text{Al}_2\text{O}_3$  consisting essentially of the  $\kappa$ -phase. However, the layer may contain small amounts,  $1\text{-}3\text{ vol-\%}$ , of the  $\theta$ - or the  $\alpha$ -phases as determined by XRD-measurement. The  $\text{Al}_2\text{O}_3$ -layer has a thickness of  $0.5\text{-}5\text{ }\mu\text{m}$ , preferably  $0.5\text{-}2\text{ }\mu\text{m}$ , and most preferably  $0.5\text{-}1.5\text{ }\mu\text{m}$ . Preferably, this  $\text{Al}_2\text{O}_3$ -layer is followed by a further layer ( $<1\text{ }\mu\text{m}$ , preferably  $0.1\text{-}0.5\text{ }\mu\text{m}$  thick) of  $\text{TiC}_x\text{N}_y\text{O}_z$  with  $x+y+z=1$ , preferably with  $y>x$  and  $z<0.3$ , most preferable  $y>0.8$ , but the  $\text{Al}_2\text{O}_3$  layer can be the outermost layer. This outermost layer,  $\text{Al}_2\text{O}_3$  or  $\text{TiC}_x\text{N}_y\text{O}_z$ , has a surface roughness  $R_{\text{max}}\leq 0.4\text{ }\mu\text{m}$  over a length of  $10\text{ }\mu\text{m}$ . The  $\text{TiC}_x\text{N}_y\text{O}_z$ -layer, if present, is preferably removed along the cutting edge. Alternatively, the  $\text{TiC}_x\text{N}_y\text{O}_z$  layer is removed and the underlying alumina layer is partly or completely removed along the cutting edge.

The present invention also relates to a method of making a coated cutting tool insert consisting of a cemented carbide body with a composition of  $10.9\text{-}13\text{ wt\% Co}$ , preferably  $11.0\text{-}12.0\text{ wt\% Co}$ , most preferably  $11.1\text{-}11.7\text{ wt\% Co}$ ,  $0.2\text{-}1.8\text{ wt\% cubic carbides}$ , preferably  $0.4\text{-}1.8\text{ wt\% cubic carbides}$ , most preferably  $0.5\text{-}1.7\text{ wt\% cubic carbides}$  of the metals Ta, Nb and Ti and balance

WC. The cemented carbide may also contain other carbides from elements from group IVb, Vb or VIB of the periodic table. The content of Ti is preferably on a level corresponding to a technical impurity. The average grain size of the WC is in the range of about 1.5-2.5  $\mu\text{m}$ , preferably about 1.7  $\mu\text{m}$ . Onto the cemented carbide body is deposited

- a first (innermost) layer of  $\text{TiC}_x\text{N}_y\text{O}_z$  with  $x+y+z=1$ , preferably  $y>x$  and  $z<0.2$ , most preferably  $y>0.8$  and  $z=0$ , with equiaxed grains with size  $<0.5 \mu\text{m}$  and a total thickness  $<1.5 \mu\text{m}$ , preferably  $>0.1 \mu\text{m}$ , using known CVD-methods.

- a layer of  $\text{TiC}_x\text{N}_y\text{O}_z$  with  $x+y+z=1$ , preferably with  $z=0$ ,  $x>0.3$  and  $y>0.3$ , most preferably  $x>0.5$ , with a thickness of 1-8  $\mu\text{m}$ , preferably 2-7  $\mu\text{m}$ , most preferably  $<6 \mu\text{m}$ , with columnar grains and with an average diameter of about  $<5 \mu\text{m}$ , preferably 0.1-2  $\mu\text{m}$ , using preferably MTCVD-technique (using acetonitrile as the carbon and nitrogen source for forming the layer in the temperature range of 700-900  $^{\circ}\text{C}$ ). The exact conditions, however, depend to a certain extent on the design of the equipment used.

- a smooth  $\text{Al}_2\text{O}_3$ -layer essentially consisting of  $\kappa$ - $\text{Al}_2\text{O}_3$  is deposited under conditions disclosed in e.g. EP-A-523 021. The  $\text{Al}_2\text{O}_3$  layer has a thickness of 0.5-5  $\mu\text{m}$ , preferably 0.5-2  $\mu\text{m}$ , and most preferably 0.5-1.5  $\mu\text{m}$ . Preferably, a further layer ( $<1 \mu\text{m}$ , preferably 0.1-0.5  $\mu\text{m}$  thick) of  $\text{TiC}_x\text{N}_y\text{O}_z$  is deposited, but the  $\text{Al}_2\text{O}_3$ -layer can be the outermost layer. This outermost layer,  $\text{Al}_2\text{O}_3$  or  $\text{TiC}_x\text{N}_y\text{O}_z$ , has a surface roughness  $R_{\text{max}} \leq 0.4 \mu\text{m}$  over a length of 10  $\mu\text{m}$ . The smooth coating surface can be obtained by a gentle wet-blasting the coating surface with fine grained (400-150 mesh) alumina powder or by brushing (preferably used when  $\text{TiC}_x\text{N}_y\text{O}_z$  top coating is present) the edges with brushes based on e.g. SiC as



disclosed e.g. in Swedish patent application 9402543-4. The  $\text{TiC}_x\text{N}_y\text{O}_z$ -layer, if present, is preferably removed along the cutting edge. Alternatively, the  $\text{TiC}_x\text{N}_y\text{O}_z$  layer is removed and the underlying alumina layer is  
5 partly or completely removed along the cutting edge.

Example 1.

A. A cemented carbide milling tool in accordance with the invention with the composition 11.5 wt-% Co,  
10 1.25 wt-% TaC, 0.30 wt-% NbC and balance WC, with a binder phase alloyed with W corresponding to a CW-ratio of 0.93 were coated with a 0.5  $\mu\text{m}$  equiaxed  $\text{TiC}_{0.05}\text{N}_{0.95}$ -layer (with a high nitrogen content corresponding to an estimated C/N-ratio of 0.05) followed by a 4  $\mu\text{m}$  thick  
15  $\text{TiC}_{0.54}\text{N}_{0.46}$ -layer, with columnar grains by using MTCVD-technique (temperature 885-850 °C and  $\text{CH}_3\text{CN}$  as the carbon/nitrogen source). In subsequent steps during the same coating cycle, a 1.0  $\mu\text{m}$  thick layer of  $\text{Al}_2\text{O}_3$  was deposited using a temperature 970 °C and a concentration  
20 of  $\text{H}_2\text{S}$  dopant of 0.4 % as disclosed in EP-A-523 021. A thin (0.3  $\mu\text{m}$ ) layer of TiN was deposited on top according to known CVD-technique. XRD-measurement showed that the  $\text{Al}_2\text{O}_3$ -layer consisted of 100 %  $\kappa$ -phase. The cemented carbide body had a WC grain size in average of  
25 1.7  $\mu\text{m}$ . The coated inserts were brushed by a nylon straw brush containing SiC grains. Examination of the brushed inserts in a light microscope showed that the thin TiN-layer and some of the  $\text{Al}_2\text{O}_3$ -layer had been brushed away only along the cutting edge leaving there a smooth  
30  $\text{Al}_2\text{O}_3$ -surface. Coating thickness measurements on cross sectioned brushed samples showed that the outer TiN-layer and roughly half of the  $\text{Al}_2\text{O}_3$ -layer was removed along the edge line.

B. A cemented carbide milling tool in accordance  
35 with the invention with the composition 11.1 wt-% Co,

1.25 wt-% TaC, 0.30 wt-% NbC and balance WC, with a binder phase alloyed with W corresponding to a CW-ratio of 0.93 were coated with a 0.5  $\mu\text{m}$  equiaxed  $\text{TiC}_{0.05}\text{N}_{0.95}$ -layer followed by a 4  $\mu\text{m}$  thick  $\text{TiC}_{0.54}\text{N}_{0.46}$ -layer, with  
5 columnar grains by using MTCVD-technique (temperature 885-850 °C and  $\text{CH}_3\text{CN}$  as the carbon/nitrogen source). In subsequent steps during the same coating cycle, a 1.0  $\mu\text{m}$  thick layer of  $\text{Al}_2\text{O}_3$  was deposited using a temperature 970 °C and a concentration of  $\text{H}_2\text{S}$  dopant of 0.4 % as  
10 disclosed in EP-A-523 021. A thin (0.3  $\mu\text{m}$ ) layer of TiN was deposited on top according to known CVD-technique. XRD-measurement showed that the  $\text{Al}_2\text{O}_3$ -layer consisted of 100 %  $\kappa$ -phase. The cemented carbide body had a WC grain size in average of 1.8  $\mu\text{m}$ . The coated inserts were  
15 brushed by a nylon straw brush containing SiC grains. Examination of the brushed inserts in a light microscope showed that the thin TiN-layer and some of the  $\text{Al}_2\text{O}_3$ -layer had been brushed away only along the cutting edge leaving there a smooth  $\text{Al}_2\text{O}_3$ -surface. Coating thickness  
20 measurements on cross sectioned brushed samples showed that the outer TiN-layer and roughly half of the  $\text{Al}_2\text{O}_3$ -layer was removed along the edge line.

C. A strongly competitive cemented carbide grade from an external leading carbide producer was selected  
25 for comparison in a milling test. The carbide had a composition of 11.4 wt-% Co, 0.1 wt-% TiC, 1.9 wt-% TaC, 0.4 wt-% NbC balance WC and a CW-ratio of 0.90. The WC-grain size was 1.4  $\mu\text{m}$ . The insert had a PVD-coating consisting of total 5  $\mu\text{m}$  of TiN/TiC/TiC,N/TiC layers.

30 D. A strongly competitive cemented carbide grade from an external leading carbide producer was selected for comparison in a milling test. The carbide had a composition of 11.5 wt-% Co, 0.2 wt-% TiC, 1.4 wt-% TaC, balance WC and a CW-ratio of 0.97. The WC-grain size was  
35 1.5  $\mu\text{m}$ . The insert had a conventional CVD-coating

consisting of total 4.8  $\mu\text{m}$  of TiN/TiC,N/TiC layers.

Operation: Face milling-roughing, cutter  
diameter. 160 mm

5 Work-piece: Connecting rod for ship  
Material: 6S42CrMo4V-cast skin, 260HB  
Cutting speed: 151 m/min  
Feed rate/tooth: 0.15 mm/rev.  
Depth of cut: 2-3 mm  
10 Insert-style: TPKN 2204 PDR  
Note: 10 inserts, dry, overhang, some  
vibrations

	Results:	Tool-life, min:
15	Grade A:	26
	Grade B:	39
	Competitor C (prior art):	1.3
	Competitor D (prior art):	13

20 Tool-life criteria were chipping of the edge line  
and breakages.

#### Example 2.

25 E. A cemented cutting tool with the composition of  
8.0 wt-% Co, 0.1 wt-% TiC, balance WC and CW-ratio of  
0.88. The WC-grain size was 3.2  $\mu\text{m}$ . The insert had a  
conventional CVD-coating consisting of total 2.5  $\mu\text{m}$   
TiC/TiC,N/TiN.

30 Inserts from A, B, C and E were tested in a face  
milling operation.

Operation: Face milling, R260.22-250  
Work-piece: Bar, 200x250 mm with holes  
Material: SS2541  
Cutting speed: 100 m/min  
5 Feed rate/tooth: 0,4 mm/rev.  
Depth of cut: 2 mm  
Insert-style: SEKN 1204  
Note: offset 20 mm, single tooth, dry,  
different exit angles due to the  
10 holes, some vibrations

	Results:	Tool-life, min
	Grade A:	132
	Grade B:	19
15	Competitor C (prior art):	13
	Competitor E (prior art):	7

Tool-life criteria were edge-line chipping and bulk  
breakages.

20

Example 3.

F. A cemented cutting tool identical to the one  
mentioned in example A except that the coating was not  
brushed.

25 G. A cemented cutting tool identical to the one  
mentioned in example B except that the coating is  
brushed differently. Examination of the brushed inserts  
in a light microscope showed that the thin TiN-layer had  
been brushed away only along the cutting edge leaving  
30 there a smooth Al<sub>2</sub>O<sub>3</sub>-layer surface. Coating thickness  
measurements on cross sectioned brushed samples showed  
no reduction of the coating along the edge line except  
for the outer TiN-layer that was removed.

H. A strongly competitive cemented carbide grade  
35 from an external leading carbide producer was selected

for comparison in a milling test. The carbide had a composition of 9.5 wt-% Co, 6.6 wt-% TiC, 12.7 wt-% TaC, 1.4 wt-% NbC, balance WC and a CW-ratio of 0.83. The insert was uncoated.

- 5 Inserts from A, B and F were tested in a face milling operation.

Operation: Face milling-roughing, R282.2-200-30  
Work-piece: Plate, 800x4200 mm  
10 Material: Fe, forging skin, sand inclusions,  
150-250 HB  
Cutting speed: 100 m/min  
Feed rate/tooth: 0,19 mm/rev.  
Depth of cut: 6-8 mm  
15 Insert-style: TPKN 2204 PDR  
Note: dry, 11 teeth, heavy vibrations

Results:	Tool-life, min:
Grade F:	26
20 Grade G:	26
Competitor H (prior art):	7

Tool-life criterion was chipping of the edge.

25 Example 4.

I. A cemented cutting tool with the composition of 9.1 wt-% Co, 1.2 wt-% TaC, 0.3 wt-% NbC, balance WC and CW-ratio of 0.89. The WC-grain size was 1.7  $\mu\text{m}$ . The insert had the same coating as mentioned in example A.

- 30 Inserts from A, B, E and G were tested in a square-shoulder test.

Operation: Full slot, widening, 0 exit angle,  
R290.90-063Q22-12M

Work-piece: Bar, 200x600 mm

Material: SS1672, rusty surface, 150 HB

5 Cutting speed: 181 m/min

Feed rate/tooth: 0,17 mm/rev.

Depth of cut: 3-5 mm

Insert-style: R290.90-12T308PPM-WM

10 Note: dry, 5 teeth, recutting of chips

Results: Tool-life, min:

Grade A: 63

Grade B: 46

Competitor E (prior art): 25

15 Competitor I (prior art): 5

Tool-life criterion was chipping in the edge line  
due to plastic deformation.

#### Example 5.

20 J. A cemented cutting tool identical to the one  
mentioned in example A, but the brushing was different.  
Examination of the brushed inserts in a light microscope  
showed that the thin TiN-layer and the Al<sub>2</sub>O<sub>3</sub>-layer had  
been brushed away only along the cutting edge leaving  
25 there a smooth TiC<sub>0.54</sub>N<sub>0.46</sub>-surface. Coating thickness  
measurements on cross sectioned brushed samples showed  
no reduction of the TiC<sub>0.54</sub>N<sub>0.46</sub>-layer, but the outer  
TiN-layer and the Al<sub>2</sub>O<sub>3</sub>-layer were removed along the  
edge line.

30 Inserts from C, D, E, I and J were tested in a face  
milling operation. Two parallel bars each of a thickness  
of 35 mm were central positioned relatively the cutter  
body, and the bars were placed with an airgap of 10 mm  
in between.

35

Operation: Face milling,  
Work-piece: 2 bars, 35x600 mm  
Material: SS1672, rusty surface, 150 HB  
Cutting speed: 230 m/min  
5 Feed rate/tooth: 0,28 mm/rev.  
Depth of cut: 3 mm  
Insert-style: SPKN 1203 EDR  
Note: wet, one tooth

10 Results: Tool-life, min:  
Grade J: 27  
Competitor C (prior art): 18  
Competitor D (prior art): 22  
Competitor E (prior art): 15  
15 Competitor I (prior art): 22  
Tool-life criterion was chipping due to comb crack formation.

Example 6.

20 Inserts from A and E were tested in a turning test.

Operation: Facing  
Work-piece: Cylinder, 180 mm  
Material: SS2541, 300 HB  
25 Cutting speed: 220 m/min  
Feed rate: 0,3 mm/rev.  
Depth of cut: 2 mm  
Insert-style: CNMG 120408-PM  
Note: dry

30 Results: Tool-life, min:  
Grade A: 5  
Competitor E (prior art): 4  
Tool-life criterion was plastic deformation.

Example 7.

Inserts from A and E were tested in a turning operation in stainless steel.

5        Operation:        Facing and longitudinal turning  
         Work-piece:     Cylinder, 96 mm  
         Material:        Sanmac 304L  
         Cutting speed:   200 m/min  
         Feed rate:        0,3 mm/rev.  
10       Depth of cut:     2 mm  
         Insert-style:    CNMG 120408-PM  
         Note:            wet

         Results:                      Tool-life, min:  
15       Grade A:                        4  
         Competitor E (prior art): 3

         Tool-life criterion was flank wear due to plastic deformation.

20

Example 8.

         Inserts from A and E were tested in a turning operation in low alloyed steel.

25       Operation:        Facing, edge-line flaking test  
         Work-piece:     Pre-machined cylinder, 150 mm  
         Material:        SS 2172  
         Cutting speed:   130 m/min  
         Feed rate:        0,2 mm/rev.  
30       Depth of cut:     2 mm  
         Insert-style:    CNMG 120408-PM  
         Note:            dry, five inserts per variant were tested



Results: Edge-line flaking, %

Grade A: 5

Competitor E (prior art): 21

5

The result is given as a mean-value after one cut.  
Five inserts per variant were tested.

Claims

1. A cutting tool insert particularly useful for wet or dry machining of low and medium alloyed steels, stainless steels, with or without raw surfaces
- 5 comprising a cemented carbide body and a coating characterized in that said cemented carbide body consists of WC with an average grain size of 1.5-2.5  $\mu\text{m}$ , preferably about 1.7  $\mu\text{m}$ , 10.9-13, preferably 11-12 wt-% Co and 0.2-1.8 wt-% TaC+NbC, and a low W-alloyed
- 10 binder phase with a CW-ratio of 0.87-0.99 and in that said coating consist of
- a first (innermost) layer of  $\text{TiC}_x\text{N}_y\text{O}_z$  with  $x+y+z=1$ , preferably  $y>x$  and  $z<0.2$ , with a thickness of 0.1-1.5  $\mu\text{m}$ , and with equiaxed grains with size  $<0.5 \mu\text{m}$
  - 15 - a layer of  $\text{TiC}_x\text{N}_y\text{O}_z$  with  $x+y+z=1$ , preferably  $z=0$ ,  $x>0.3$  and  $y>0.3$ , with a thickness of 1-8  $\mu\text{m}$  with columnar grains with a diameter of about  $<5 \mu\text{m}$
  - a layer of a smooth, fine-grained (0.5-2  $\mu\text{m}$ )  $\kappa\text{-Al}_2\text{O}_3$  with a thickness of 0.5-5  $\mu\text{m}$  and
  - 20 - preferably an outermost layer of  $\text{TiC}_x\text{N}_y\text{O}_z$ , preferably TiN, with a thickness of  $<1 \mu\text{m}$ .
2. Cutting insert according to claim 1 characterized in that the cemented carbide has the composition 11.1-11.7 wt-% Co and 0.5-1.7 wt%
- 25 TaC+NbC.
3. Cutting insert according to any of the preceding claims characterized in a CW-ratio of 0.90-0.95.
4. Cutting insert according to any of the preceding
- 30 claims characterized in that the outermost  $\text{TiC}_x\text{N}_y\text{O}_z$ -layer, if present, has been removed along the cutting edge.
5. Cutting insert according to any of the preceding claims characterized in that the  $\kappa\text{-Al}_2\text{O}_3$ -
- 35 layer has been removed along the cutting edge.

6. Method of making a cutting insert comprising a cemented carbide body and a coating

characterized in that the WC-Co-based cemented carbide body consisting of WC with an average grain size of 1.5-2.5  $\mu\text{m}$ , preferably about 1.7  $\mu\text{m}$ , 10.9-13, preferably 11-12 wt-% Co and 0.4-1.8 wt-% TaC+NbC, and a low W-alloyed binder phase with a CW-ratio of 0.87-0.99 is coated with

- a first (innermost) layer of  $\text{TiC}_x\text{N}_y\text{O}_z$  with  $x+y+z=1$ , preferably  $y>x$  and  $z<0.2$ , with a thickness of 0.1-1.5  $\mu\text{m}$ , with equiaxed grains with size  $<0.5 \mu\text{m}$  using known CVD-methods

- a layer of  $\text{TiC}_x\text{N}_y\text{O}_z$  with  $x+y+z=1$ , preferably with  $z=0$  and  $x>0.3$  and  $y>0.3$ , with a thickness of 1-8  $\mu\text{m}$  with columnar grains with a diameter of about  $<5 \mu\text{m}$  deposited by MTCVD-technique, using acetonitrile as the carbon and nitrogen source for forming the layer in a preferred temperature range of 850-900  $^\circ\text{C}$ .

- a layer of a smooth  $\text{K-Al}_2\text{O}_3$  with a thickness of 0.5-5  $\mu\text{m}$  using known CVD-methods and

- preferably a layer of TiN with a thickness of  $<1 \mu\text{m}$ .

7. Method according to the previous claim characterized in that said cemented carbide body has the composition 11.1-11.7 wt-% Co and 0.5-1.7 wt% TaC+NbC.

8. Method according to any of the claims 6 and 7 characterized in a CW-ratio of 0.90-0.95.

9. Method according to any of the claims 6, 7 and 8 characterized in that the outermost  $\text{TiC}_x\text{N}_y\text{O}_z$  layer, if present, is removed along the cutting edge.

10. Method according to any of the claims 6, 7 and 8 characterized in that the  $\text{Al}_2\text{O}_3$ -layer is removed along the cutting edge.

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 96/01579

## A. CLASSIFICATION OF SUBJECT MATTER

IPC6: C23C 16/30, C23C 16/40, C23C 30/00, B23B 27/14  
According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: C23C, B23B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

JAPIO

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim N
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Y	EP 0709484 A1 (MITSUBISHI MATERIALS CORPORATION), 1 May 1996 (01.05.96), page 2, line 30 - line 52; page 4; page 6 --	1-10
Y	EP 0686707 A1 (MITSUBISHI MATERIALS CORPORATION), 13 December 1995 (13.12.95), page 2, line 1 - line 18; page 4, line 9 - line 12, claim 1 --	1-10

☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.

## \* Special categories of cited documents:

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 "P" document published prior to the international filing date but later than the priority date claimed

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"&" document member of the same patent family

Date of the actual completion of the international search

18 February 1997

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## INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 96/01579

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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Y,P	EP 0693574 A1 (SANDVIK AKTIEBOLAG), 24 January 1996 (24.01.96), claims 5,6 --	4,5,9,10
Y	US 4643620 A (HIROSHI FUJII ET AL), 17 February 1987 (17.02.87), column 2, line 8 - line 30; column 3, line 42 - line 44; column 3, line 59 - line 66, figure 5C, abstract -----	4,5,9,10

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Information on patent family members

03/02/97

International application No.

PCT/SE 96/01579

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